Innovazione tecnologica e paradossi della regolazione: perché i Veicoli Elettrici potrebbero aumentare le emissioni di CO2
EV claims

- EV will develop
- If "everyone" says EV will have a large diffusion, how could it be wrong?
- EV diffusion is good for society
  - «EV are Zero Emissions on the road...»
  - ... but emit in the plant»
  - «Emissions can be estimated on energy mix»
  - «Emissions during car manufacturing can be neglected as a first approximation»
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Emissions in power plants?

- Electrification =>
  - Shift of non capped sector to capped sector
  - Cap disconnected from the evolution of energy needs
  - Social cost but not in terms of emissions
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Regulation 443 and on the road emissions

- Regulation EU 443 principles
- Optimal emissions
  - Without regulations
  - With regulations
  - Effect of EV diffusions on fleet emissions with regulation
Regulation 443

- **Target**
  - From 2015: 130 g/km
  - From 2020: 95 g/km (tentative)

- **Computation features**
  - Mass
  - % of fleet
  - Pooling
  - Super credit
  - 0 emissions

- **Penalty**

- **Exemptions**
  - Niche manufacturer
CO2 outcomes: an apparent success

Figure 1: Historical development and future targets for CO₂ emission levels of new passenger cars in the EU. Effects of phase-in, super-credits and eco-innovations not shown here.

Fonte: figure 1 in (ICCT International Council of Clean Transportation 2015)
- Regulation EU 443: principles
- Optimal emissions
  - Without regulations
  - With regulations
  - Effect of EV diffusions on fleet emissions
- Profit maximizing
  - Production costs
  - Wtp for more efficient car
- Regulation EU 443: principles
- Optimal emissions
  - Without regulations
  - With regulations
  - Effect of EV diffusions on fleet emissions
"Zero emissions" on the road? The effect of regulation 443

- Emissioni ottimali senza regolazione
  - $w(e)$
  - $w(e) - c(e)$
  - $c(e)$
  - Emissioni ($gkm$)

Limite di redditività

- Livello di emissioni dove i costi marginali di riduzione si uguagliano con la penale
  - $\lim (0; p^*(e-T))$
  - $w(e)$
  - $w(e) - c(e)$
  - $c(e)$
  - Emissioni ($gkm$)

Secondo i valori di $T$

<table>
<thead>
<tr>
<th>Strategia ottimale</th>
<th>Pagare penalità</th>
<th>Rispettare soglia</th>
<th>Non cambiare niente</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissioni ottimali</td>
<td>$E$</td>
<td>$T$</td>
<td>$e^*_0$</td>
</tr>
<tr>
<td>Penali pagate</td>
<td>$p^*(E-T)$</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Higher penalties

Tighter target

Target driven

Penalty driven

Uneffective
Emissioni ottimali \( f(T,p) \)

Target

Penalty

Emissions

- 130-140
- 120-130
- 110-120
- 100-110
- 90-100
- 80-90
Regulation EU 443: principles

Optimal emissions
- Without regulations
- With regulations

Effect of EV diffusions on fleet emissions
Simpliest model:

- 2 tecn.
  1 = polluting
  2 = zero emissions
- Wtp(e)
- c(e)
- Exog. Quantities
- No mark up
- Target $T$ is bounding.

\[
\max_{e_1} \Pi = \overline{Q}_1(p_1 + w(e_1) - c_1(e_1)) + \overline{Q}_2(p_2 + w(0) - c_2(0))
\]

\[
st \left( \frac{e_1 \overline{Q}_1}{\overline{Q}_1 + \overline{Q}_2} < T \right)
\]

\[
\max_{e_1} L(e_1; \lambda) = \overline{Q}_1(p_1 + w(e_1) - c_1(e_1)) + \overline{Q}_2(p_2 + w(0) - c_2(0))
\]

\[- \lambda \left( \frac{e_1 \overline{Q}_1}{\overline{Q}_1 + \overline{Q}_2} - T \right)\]

\[
\frac{\partial L(e_1; \lambda)}{\partial e_1} = 0 \Rightarrow \overline{Q}_1(w'(e_1^*) - c_1'(e_1^*)) - \lambda \left( \frac{\overline{Q}_1}{\overline{Q}_1 + \overline{Q}_2} \right) = 0
\]

\[
\Rightarrow \lambda = (w'(e_1^*) - c'(e_1^*))
\]

\[
\frac{\partial L(e_1; \lambda)}{\partial e_1} = 0 \Rightarrow \frac{e_1 \overline{Q}_1}{\overline{Q}_1 + \overline{Q}_2} = T \Rightarrow e_1^* = T \frac{\overline{Q}_1 + \overline{Q}_2}{\overline{Q}_1}
\]

Average emissions for two technologies:

\[
\frac{\overline{Q}_1(T \frac{\overline{Q}_1 + \overline{Q}_2}{\overline{Q}_1} + \overline{Q}_2 \times 0)}{(\overline{Q}_1 + \overline{Q}_2)} = T
\]

Invariant with respect to Q2.
Abbildung 43: Ausgabematrix Wohlfahrtsanalyse MMEM „110g in 2020“
## Conclusions 2 - EV emissions

<table>
<thead>
<tr>
<th>Emissions categories</th>
<th>Elettric Vehicles</th>
<th>Conventional vehicles</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dominating conception</td>
<td>Technical $^a$</td>
<td>Emissions based on regulations (ETS e 443)</td>
</tr>
<tr>
<td>W2T</td>
<td>40-100 C.E.$^\dagger$ = 65</td>
<td>95$^c$</td>
<td>0 (ETS)</td>
</tr>
<tr>
<td>T2W</td>
<td>0</td>
<td>0</td>
<td>trans.$^\dagger\dagger$ (e*$&lt;$T) = 0 regime (e*$&gt;$T) = T</td>
</tr>
<tr>
<td>Manufacturing$^b$</td>
<td>Usually omitted</td>
<td>34-95 C.E. = 65</td>
<td>34-95 C.E. = 65</td>
</tr>
<tr>
<td>Extra sales</td>
<td>0</td>
<td>0</td>
<td>A regime: x (not quantified)$^d$</td>
</tr>
<tr>
<td>Total</td>
<td>40-100 C.E. = 65</td>
<td>95 + 65</td>
<td>trans. (e*$&lt;$T) = 65 regime (e*$&gt;$T) = 65+T+x</td>
</tr>
</tbody>
</table>

$^\dagger$ “C.E.”: central estimate
$^\dagger\dagger$ “trans.$^\dagger$”: situazione di transizione.
$^a$ – senza considerare gli effetti della regolazione.
$^b$ - su km totale percorsi.
$^c$ - stima in Massiani e Byloos, forthcoming.
$^d$ - La riduzione delle emissioni nel parco convenzionale consente una riduzione del costo di produzione del veicolo portando a una maggiore diffusione delle automobili, e a un aumento delle emissioni.
Results

- When car manufacturer choose optimal emissions based on emissions reductions costs, penalties and consumer wtp
- Optimal emissions determined based on three regimes
  - Unbounding
  - Bounded by Penalty
  - Bounded by Target.
- When "0 emission vehicles" are introduced, emission reductions compensated by increase in emissions in ICE
- In transitory phase (when regulation is not bounding), EV can reduce emissions
- In the long run, when regulation is bounding, EV can increase emissions
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Thank you for your attention
Merci pour votre attention
Grazie per l'attenzione
Research on Electric Vehicles

- **Autolib tender**
  - Ratp and Significance (2010)

- **Research project for BundesMinisterium fuer Umwelt**
  - EMOB model developed at ESMT – Berlin on Goldsim platform

- **Ongoing research in Ca' Foscari University**
  - Research in Transportation Economics, Special Issue on Electric vehicles: Modelling demand and market penetration

- **Cost-Benefit Analysis of policies for the development of electric vehicles in Germany: Methods and results**, 2015
  - *Transport policy*, vol. 38, pp. 19-26

- “I veicoli elettrici, strumento ambiguo di riduzione delle emissioni di CO2, fra determinanti tecnologiche e paradossi della regolazione”, 2015, with M. Byloos.
  - *Rivista di Economia e Politica dei Trasporti*, vol. 3

  - *Research in Transportation Economics*, vol. 50, pp. 17-28

  - L’auto elettrica come innovazione radicale: scenari di penetrazione di mercato e ricadute economiche e sociali, Trieste, EUT Edizioni Università di Trieste, pp. 77-89

- “Stated Preferences Surveys for Alternative Fuel Vehicles: are we doing the right thing?” 2014

- “Using Stated Preferences to forecast alternative fuel vehicles market diffusion”, 2012

- “Estimating electric car’s emissions in Germany: an analysis through a pivotal marginal method and comparison with other methods”, 2012, with Weimann, J.,